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(57) Abstract

A method and a device for immediate, continuous and simultaneous qualitative and quantitative determination of a plurality of parameters describing the condition or quality of an organic matter, based on the dielectric properties of the matter. Where a primary emission spectrum with known spectral data and comprising electromagnetic radiation with a known frequency spectrum of a plurality of wavelengths within the frequency range of 0.3 – 1000 MHz is emitted towards the organic matter by one or several electrodes. The emitted primary emission spectrum generates, in interaction with the organic matter, at least one secondary spectrum. The generated secondary spectrum is registered by one or several electrodes, whereupon the emitted primary emission spectrum and the generated secondary spectrum are compared. The alterations in spectral data between the primary emission spectrum and the generated secondary spectrum is detected, whereupon detected alterations in spectral data between primary and secondary spectrum are correlated against a plurality of quality describing variables, quality variables, of the investigated matter.

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METHOD AND DEVICE FOR DETERMINING A PLURALITY OF QUALITY VARIABLES WHICH DESCRIBE THE CONDITION OF AN ORGANIC MATTER

TECHNICAL FIELD

The invention relates to an immediate and continuous method in order to simultaneously and quantitatively determine a plurality of variables describing the condition or quality of an organic matter by using the dielectric properties of the organic matter. The invention also relates to a device for carrying through the invented method. The invention is principally intended for quality determination of solid organic material of biological origin, which comprises solid components fully or partly separated by gas, such as chips, timber, peat, biomass, but the invention is also useful for determination of quality variables of organic matter, which is to be recycled. The solid components can consist of fine particles, such as sawdust, wood flour, grinded grains, but also larger pieces such as timber, plastic goods etc.

STATE OF THE ART

Organic matter, such as wood, in the form of firewood, timber, chips or fibres, peat, biomass and certain fossile matter is used as raw material or admixture substance in industrial processes or as fuel in heat- and power generating incineration plants. In order to use the matter optimally and avoid disturbances in a following process or that a defect product is produced, it is desirable to continuously be able to determine the quality of the matter, before or in connection to when it is brought to a plant or a process. Examples of variables, in the following named quality variables, which influence the possibility to use the organic raw material or which influence the prerequisite or operating conditions for the current process and which therefore should be determined, are moisture content, the condition of the

water, i.e. the ratio ice/water, the content of extract substances and the presence and extent of biological damaged matter. By biological damaged matter is meant matter with damages resulting from attacks from rot fungus or other microorganisms. Other quality variables possible to be determined are the distribution between different sort of wood, for example expressed as the ratio between coniferous/deciduous tree, the existence of different firewood structures, such as tension wood, reaction wood etc. At analysis of recycled plastics, the existence of and content of different plastic materials can be determined.

Normally, the quality of biological matter such as wood, peat or biomass is determined by manual inspection and discrete sample collection, followed by analysis in a laboratory. It is known to determine the moisture content continuously by microwave and infrared technology, however, such measurement only gives information of the surface moisture content.

By the international patent document WO 95/24818 it is known, in connection with drying/heat treatment of biological material by high frequency electromagnetic radiation within the wavelength range 0.3 - 299 MHz, to determine moisture content by registering the absorbance of the matter of the electromagnetic radiation emitted towards the matter at a specific wavelength. The absorbance is then related to a moisture content by being compared with reference values. Furthermore, it is by this document known to supply the biological matter withan electromagnetic radiation of one or several frequencies or a radiation, the frequency of which oscillates within a suitable frequency interval by one or several antennas to optimise the heating. However, registering of the absorbance is performed by only one detector, normally an antenna, which solely registers at one frequency and solely for monitoring the moisture content and from the moisture content control the heat treatment. Furthermore, measuring

according to this method demands a cavity or measurement chamber which is geometrically adjusted to the measurement frequency, i.e. the frequency which is registered by the detector.

According to the European patent document EP-A-0 295 308 it is known to supervise two components of a cigarette during or after fabrication, by directed electromagnetic radiation comprising at least two discrete frequencies in the gigahertz range, 0.1 - 100 GHz, by registering the dispersion intensity by detectors for at least two frequencies. This method, operating with wavelengths less than the solid components in the investigated matter and with directed radiation, demands that the objects, cigarettes, are oriented relative to used radiation sources and detectors and that the cigarettes maintain this orientation during passage past the detectors. Furthermore, this method is intended for solid objects with solid components, which preferably present substantially constant dimensions.

It is known that a plurality of variables can be determined simultaneously by correlating a number of measured values to each other by algorithms, statistical models and data analysis methods, such as for instance Partial Least Square regression (PLS), principal component analysis (PCA), multi linear regression analysis (MLR) and neural networks. Usually, the models and algorithms used in the data analysis are created and calibrated from calibration and reference measurements, which are performed for a number of reference samples with known quality defining properties, quality variables. These data analysis methods and other methods for multivariate data analysis, where measurement values are correlated to variables so as to determine a number of independent variable values from a relatively limited number of values, are established technology, which is generally known and used within the chemistry area and in particular within the area of chemical

analysis. In the following in this application, these methods are named multivariate correlation - and a calibration based on such a method - multivariate calibration.

A purpose of the present invention is to instruct of a reliable method and a simple device in order to immediately, continuously and simultaneously determine a plurality of variables which describes the state or quality of a biological matter before or in connection with the supply as raw material, fuel or admixture to a plant or process, or when it results as a intermediate product or end product in a process. The invented method and device should be possible to use on organic matter which comprise solid components, fully or partly separated by gas, and where the size of the solid components varies. This can be matter comprising fine solid components such as grinded grains, wood flour, sawdust, chips and the like but also coarser matter such as recycled material of paper, cardboard, plastics etc., delivered in bulk or piece material such as wood in piles or stacks. The method should also be substantially independent of the orientation of the measurement object, which is a prerequisite for enabling measurements on bulk material. Furthermore, due to the use, the method should be able to perform in existing spaces, such as material pockets, along conveyor belts etc., the dimensions of which are determined by the production capacity of the plant and does not need to be adjusted to the measurement device. Accordingly, the method is not bound to be performed in a specially adjusted measurement compartment. It is also a purpose of the invention to instruct of a method and a device where a process can be controlled substantially on-line from the measured quality variables.

THE INVENTION

To achieve these aims, the present invention propose an immediate and continuos method in order to qualitatively and

quantitatively and simultaneously determine a plurality of variables describing the state or quality of an organic matter and where the determination of the variables is based on the dielectric properties of the matter according to the preamble of claim 1. The invented method is characterised by the features stated in the characterising part of claim 1; that an organic matter is introduced in a measuring cell comprising a plurality of electrodes,

- that a primary emission spectrum with known spectral data and comprising electromagnetic radiation with a known frequency spectrum of a plurality of wavelengths within the frequency range of 0.3 to 1000 MHz, preferably within 0.3 MHz to 500 MHz, is emitted towards the organic matter in the measuring cell by one or several of the electrodes,
- that at least one secondary spectrum comprising a plurality of wavelengths is generated by the emitted primary emission spectrum by interaction with the organic matter,
- that the generated secondary spectrum is registered by one or several of the electrodes,
- that the emitted primary emission spectrum and the generated secondary spectrum are compared and
- that alterations in spectral data between the primary emission spectrum and the generated secondary spectrum are detected, whereupon the detected alterations in spectral data between primary and secondary spectra are correlated to a plurality of quality describing variables, quality variables, of the investigated material. Preferably, the investigated organic matter comprises solid components, which fully or partly are separated by a gas. By interaction between the primary emission spectrum and the matter is meant the influence that the dielectric properties of the matter have on the secondary spectrum generated when electromagnetic radiation included in the primary emission spectrum strikes and passes the matter and/or is reflected by the matter.

According to one embodiment of the method according to the present invention, the spectral data of the primary emission spectrum and the secondary generated spectrum are compared, whereby alterations in spectral data are detected as a comparison spectrum comprising spectral data for a plurality of wavelengths. The comparison spectrum can consider the phase, amplitude, impedance of the radiation or the like. From this spectrum, certain variables can be derived or extracted such as Q value, cole-cole parameters and the like. Such variables, extracted from the comparison spectrum, can be included in a data matrix, which is processed by multivariate data analysis according to the description below. According to a preferred embodiment, the comparison spectrum is achieved as the ratio of the primary emission spectrum and the generated secondary spectrum. The obtained comparison spectrum is correlated to a plurality of quality variables of an investigated matter of biological origin. One or several variables can also be extracted or detected directly from the comparison spectrum, whereupon such a variable detected from the comparison spectrum is correlated to a plurality of quality variables of an investigated matter of biological origin.

The present invention is particularly suited for quality determination of solid organic matter with biological origin, which comprises components fully or partly separated by gas, such as chips, wood, peat, biomass, but the invention is also useful for determination of quality variables of certain fossile matter of biological origin and for determination of quality variables of organic matter which is to be recycled. The solid components can be fine particles such as sawdust, wood flour, grinded grains, but also larger pieces as wood, plastic articles etc. The present invention also presents the advantage that it is substantially independent of variations in the size of the solid components and thereby well suited for this type of analysis where the size of the object matter

strongly varies. In contrast to known technology, the present invention does not require a measurement cell adjusted to used wavelengths, neither the measuring objects have to be oriented relative to the electrodes.

According to a preferred embodiment of the invention, an emission spectrum is used comprising electromagnetic radiation with wavelengths exceeding the cross dimensions of the solid components. By cross dimension is in this application meant;
- for a substantially uniform solid body or particle, size in an arbitrary direction, but
- for an elongated object, such as a log, a pole, sawed timber or the like, the dimension in the longitudinal direction, axial direction, is excluded.

According to a particularly useful embodiment of the invention, a transmittance spectrum is registered, which is generated in connection with that the emitted primary emission spectrum to a certain extent passes, is transmitted, through the organic matter. Arisen secondary transmittance spectra are registered by one or several electrodes. The primary emission spectrum and the secondary transmittance spectrum are compared and alterations in the spectral data of the secondary transmittance relative to the spectral data of the primary emission spectrum is detected, preferably as a comparison spectrum, as already has been described above. The comparison spectrum or in another way detected alterations of the spectral data is thereupon correlated to a plurality of quality describing variables, quality variables, for the investigated matter.

In order to send out a primary emission spectrum and to register an arisen secondary spectrum, a measurement cell is used, which comprises one or several electrodes. The comparison between primary and secondary spectra, the production of the comparison spectrum or other detection of

the alterations in spectral data between the primary emission spectrum and the secondary spectrum and the correlation of the comparison spectrum or alterations in spectral data, detected in another way, to a plurality of quality variables take place in an evaluation unit. The evaluation unit comprises means in form of electronic units and software for said detection, comparison and correlation. Said electronic units comprises means with associated software, which are disposed to communicate with the electrodes of the measurement cell, to control and receive data from the electrodes. The electronic units also comprise means with associated software for said detection, comparison and correlation. Comparison spectrum or alterations in spectral data between the primary emission spectrum and the generated secondary spectrum, detected in another way, as well as variables which are extracted directly from the comparison spectrum are correlated thereby with a plurality of quality variables by a method for multivariate data analysis by using models and algorithms, which has been created and calibrated from alterations in spectral data between a primary spectrum and a secondary spectrum detected in measurements made for a number of reference samples with known values of the current properties, quality variables. At the correlation, algorithms and statistical methods included in multivariate data analysis methods are used, such as for instance Partial Least Square regression (PLS), principal component analysis (PCA), multi linear regression analysis (MLR) or in a neural network.

According to an embodiment, the detected alterations in spectral data between the primary spectrum and the secondary spectrum are correlated to quality variables for the investigated matter by use of models and algorithms for Partial Least Square regression (PLS), created and calibrated from a set of reference samples.

According to an alternative embodiment, the detected alterations in spectral data between the primary emission spectrum and the secondary spectrum are correlated to quality variables by a neural network by use of models and algorithms for multivariate data analysis created and calibrated from a set of reference samples.

Preferably, the method is used for to simultaneously determine a plurality of quality variables for matter with biological origin, which comprises solid components, fully or partly separated by gas, such as wood, in form of firewood, timber, chips or fibres, peat, or biomass. The method is also used in order to determine quality variables for certain fossile matter at the prospect of using them as raw material in industrial processes or as fuel in heat or power generating incineration plants, as well as in order to qualitatively and quantitatively analyse matter by determine a plurality of quality variables at the prospect of recycle the matter as waste paper, waste cardboard and recyclable plastics. Also, the invention is used by simultaneous determination of a plurality of quality variables for intermediate products in an on-going process or in order to determine quality variables for an end product. Most of this matter normally present a large variation in many properties, such as strongly varying object size, varying degree of packing, i.e. bulk density.

Examples of alterations between spectral data of a primary emission spectrum and of a generated secondary spectrum, which are detected as comparison spectrum or in another suitable manner are those dependent of absorbance at different wavelengths. The absorbance gives information about the content of water and functional organic chemical groups with dipole character in the organic matter. From this, the composition of the matter, the presence of certain substances, such as extract substances, the presence of microorganisms and products produced as a result of attacks from microorganisms

in the biological matter can be determined. In certain embodiments, where the alterations in spectral data substantially relates to absorbance at different wavelengths, the alterations are registered in form of an absorbance spectrum comprising a plurality of wavelengths. Other alterations of spectral data between the primary emission spectrum and the secondary spectrum, which are detected, are such that are depending on transmittance at different wavelengths, reflectance at different wavelengths, phase shifts at different wavelengths, polarisation at different wavelengths.

According to an embodiment of the invention, which improves the possibility to quantitatively determine the absolute values of the quality variables, at least one additional variable is determined. For example, one or more of the following variables are determined: temperature, weight, volume, density of the matter. This variable is determined independent of the electromagnetic radiation measurement. This or these variables are then combined with the comparison spectrum or in another way detected alterations of electromagnetic spectral data between the primary emission spectrum and the generated secondary spectrum to a variable matrix. The matrix is correlated against a plurality of quality variables, which defines quality determining properties of the matter. Since the matrix comprises this additional, independent, variable in combination with the detected alterations in spectral data, the properties or variables of an investigated matter can be predicted after a multivariate calibration of the matrix for these properties. In the same manner, the matrix is used to predict process parameters in a process to which the matter is supplied or capacity of the product which is produced from the investigated matter. The calibration is then taking place against those process variables or capacity, which are to be predicted.

According to a preferred embodiment of the invention, the determined quality variables are used in order to adjust and or control a process in which the analysed organic matter is included as raw material, admixture, intermediate product and/or final product. The determined quality variables are then compared with desired guideline values of these variables in a control unit. Discrepancies found in the control unit between determined values and guideline values generates outputs, from which the current process is adjusted and/or controlled.

Alternatively, the expected process variables or capacity of a final product are predicted in manner described above, whereupon the process is adjusted if these predicted values diverge from the desired values of process variables or capacity.

An emitted primary electromagnetic emission spectrum according to the invention comprises radiation with frequencies substantially within the range of radio waves. By radio waves is in this application meant electromagnetic radiation with frequencies within the frequency interval 0.3 - 1000 MHz. Preferably, a primary emission spectrum is emitted, which has a continuos spectral distribution over the entire interval, but the spectrum emitted may also consist of radiation of a plurality of discrete wavelength or of a plurality of part spectra, which interior has a continuos spectral distribution but is separated from each other. Used radiation is preferably periodic. Preferably, an electromagnetic radiation with wavelengths exceeding the largest cross dimension of the solid components is used, as defined above.

A device suitable for accomplishing the invented method comprises a measurement cell, with one or several electrodes, and an evaluation unit. In embodiments, where it is desired to

use determined variable values to control or adjust a process, also a control unit is included. The device, which is substantially independent of the size and orientation of the measurement object as long as the used wavelengths exceed the largest cross dimension of the solid components may with advantage be disposed in existing equipment for reception, storing, input, output, and delivery, as well as other equipment for intermediate storing or transport between process steps, such as loading pockets, silos, belt or screw conveyors or the like.

The electrodes of the measurement cell are arranged to send out a primary emission spectrum of electromagnetic radiation with known spectral data and of frequencies within the specified frequency range towards an organic matter and to receive and register the secondary spectrum or spectra arising by interaction between the primary spectrum and the matter. The electrodes for sending and receiving current spectra are according to certain embodiments comprised in walls, floor and/or ceiling of a used measurement cell, but may with advantage be arranged with an open structure in connection to existing process equipment, as been described above. According to an embodiment represented in the following examples, at least one electrode is arranged in connection to a matter pockets or silo, for example in the wall of the pocket or silo. When requested, the measurement cell according to the invention may be arranged with a screen, substantially impermeable for the electromagnetic radiation, arranged around the measurement cell to prevent that radiation from the measurement cell is scattered in and in connection with the process plant, and or that the electrodes are disturbed by electromagnetic radiation present in the environment. However, this screen is not called for to perform the present invention, but only aims to minimise disturbances between equipment and environment. The invention is well suited, by its substantially independence of the design of the

measurement cell and/or the orientation of the measurement object combined with the capacity to be used at strongly varying object size, to be used on-line, in-line and at-line to determine quality variables in connection with processes in plants with a substantially continuos supply of raw material comprising solid components, which fully or partly are separated by gas, or a substantially continuos process flow of such matter. But the invention is also suitable for determining quality variables in connection with batch processes or other processes, which have a batchwise input of such raw material and where individual samples are taken of separate batches. At continuos processes or processes which have a supply of raw material which under certain time periods are substantially continuos are in many embodiments transport means arranged to substantially continuously transport matter through the measurement cell. Suitable transport means are conveyor belts, screw feeder, rotary vane feeder, flow tables etc. In applications for batch processes or for processes with batchwise input, it is more functional with discrete analysis. The size of the measurement cell then varies from small test chambers for a removed sample to embodiments with measurement cells which may contain the entire unloaded amount of cargo from lorries or railway trucks.

The evaluation unit comprises electronic means and software arranged to compare the primary emission spectrum and the secondary spectrum and thereby detect alterations in spectral data between these spectra, and means arranged to correlate said detected alterations in spectral data at a plurality of wavelengths against a plurality of quality variables which describes the state of the investigated matter. In a preferred embodiment, the evaluation unit comprises a neural network. The same neural network is in one embodiment, which is used for control or adjustment of a process, arranged with means for said adjustment/control.

According to an alternative embodiment, which is applicable for analysis of matter, where the radiation contained in the emission spectrum partly is reflected, a secondary reflectance spectrum is registered, arisen from interaction between a primary emission spectrum and the matter sample. The primary emission spectrum and the generated secondary spectrum are compared, alterations in spectral data between these spectra are detected, preferably as a comparison spectrum comprising a plurality of wavelengths, whereupon the comparison spectrum or in another manner detected alterations in spectral data are correlated against a plurality of quality describing variables, quality variables, for the investigated matter in the same way as has been described above.

According to a further embodiment, two secondary spectra are registered, which have been generated by influence of the dielectric properties of the matter on the emitted primary spectrum. Alterations in spectral data in both these generated secondary spectra relative to the primary emission spectrum are detected, whereupon the alterations in spectral data detected by said two secondary spectra are correlated against a plurality of quality variables of the investigated matter. In this manner, variations within the matter are detected with higher sensitivity and a measure of the homogeneity of certain of the quality variables are achieved.

EXAMPLES

The invention will in the following be explained more in detail and be exemplified with preferred embodiments by reference to the following examples. In the examples, the invention is used for determining quality variables of organic matter. The determination is performed partly before it is supplied to a process as raw material or admixture substance and partly as quality determination of intermediate products and end products. In all cases, the quality variables may be

related to desired guideline values to control the coming, current or former process.

EXAMPLE 1, BIOMASS FUEL AT COMBUSTION

By combustion of biomass fuel it is desirable to know the moisture content of the biomass fuel and its composition. From these variables, the calorific value of the fuel may be calculated and the combustion conditions may be adjusted by controlling the air factor at the combustion to obtain optimum performance in the view of both environment and production costs. By the composition is not meant the chemical gross composition but the distribution between different types of biomass fuels, which have different energy content, such as pellets of known composition, chips of coniferous wood, chips of deciduous wood, straw, seeds and other rest products from production of provisions etc. These variables are determined according to the invention by using the influence that the dielectric properties of the biomass fuel have on a spectrum of radio frequency radiation, whereby a primary emission spectrum with known spectral data and comprising electromagnetic radiation with a known frequency spectrum of a plurality of wavelengths within the frequency range 0.3 MHz-1000 MHz, is sent out towards the biomass fuel and that a secondary transmittance spectrum, generated by the passage of the radiation through the fuel, is registered, also at a plurality of wavelengths. Preferably, frequencies between 0.3 and 500 MHz are used. Thereupon, spectral data for secondary and primary spectra are compared, whereby alterations in spectral data are detected, suitably as a comparison spectrum, preferably obtained as the ratio between the primary emission spectrum and the generated secondary spectrum. The detected alterations in spectral data, detected by the comparison spectrum, are correlated by multivariate data analysis to the moisture content and composition of the biomass fuel. If absolute values of the moisture content are required, spectral

data should be combined with for instance temperature measurements or weighing.

In certain contexts it is desirable to know the density, why weight and volume are measured on incoming fuel. At particulate fuel, a determination of weight and volume only gives the apparent density or bulk density, if it on the contrary is desirable to know the density of the solid fuel as such, the measurements of weight and volume has to be combined with the spectral data which can be determined according to the invention. Whereupon the obtained matrix then is correlated to the density of the fuel.

The measurement cell is designed dependent on the conditions of the incineration plant and then in particular dependent on how the fuel is supplied. If conveyor bands, or other forms of conveyor means for continuos supply, is used, the measurement cell and its electrodes are arranged in connection to or conformed in walls, floor or ceiling of a measurement cell. Such a measurement cell can be constituted by a matter pocket or silo and comprises a cavity, which the matter passes. One or several electrodes are arranged within the walls of the cavity. The Q value, quality factor, is determined. The line width contains information about the absorption in the matter which passes through the measurement cell. In certain plants it is more favourable to determine the quality variables on discrete amounts. These part amounts are then often large and comprise substantially all fuel supplied to the plant. The measurement cell may be arranged so as to contain the whole load from a heavy vehicle, such as a lorry or a railway truck, introduced in the measurement cell and the quality variables are determined for the whole amount on the vehicle.

Evaluation, i.e. registering of spectral data, detection of alterations in spectral data between primary and secondary spectrum, acquisition of other actual value signals and

correlation of the collected amount of data to moisture content, composition and density are performed by conventional electronic units, for instance computers, with software comprising the algorithms, models and reference sets that is needed for the multivariate data analysis. By plants, where the quality variables are used to optimise the process, the same computers are advantageously used both for process control and evaluation, but of course, evaluation and process control may be performed by separate units or systems.

EXAMPLE 2, BIOMASS FUEL AT PELLETISING

At pelletising of biomass fuel it is desirable to know moisture content and composition, as well as the real density of the fuel to be able to produce a pelletised biomass fuel with moisture content, calorific value and density within certain predetermined intervals. Analysis of ingoing matter is made in the same manner and with the same types of measurement cell, evaluation and control units as have been described in example 1. At pelletising of biomass fuel the inventions is preferably used for controlling that the product meets set-up quality requirements. At this quality determination, the three earlier mentioned quality variables are normally determined, moisture, composition and density.

EXAMPLE 3, TIMBER

Drying of timber is a sensitive process where the process economy has to be optimised against the timber quality. At a too fast drying, the timber cracks and becomes twisted at the same time as a slow drying is not required from economical point of view. For producing timber of high quality at economically favourable conditions it is required to determine the moisture content and wood structure of the timber. By wood structure is in this application meant the growth dependent influence on the structure of wood, where a slow growth gives

a compact wood structure and a fast growth a more open porous wood structure. The moisture content and wood structure are according to the invention determined by using the influence that the dielectric properties of the timber have on a spectrum of radio frequency radiation. Moisture content and wood structure are used for adjusting the drying process. Either, a drying scheme is calculated with determined variations of moisture and temperature over time from the determined quality variables. Alternatively, the determined variables moisture and structure are used to predict a suitable moisture and temperature profile, which is maintained during the drying process. The drying process is then controlled to follow the predicted profile while the moisture content in the timber is monitored continuously or by discrete measurements by using radio frequency radiation and the dielectric properties of the timber according to the invention, whereby discrepancies in the present value of the moisture content of the timber gives signals which controls the drying process.

Normally, moisture and wood structure are determined in the drying oven, drying room or autoclave while evaluation unit and control unit in the above mentioned manner is comprised in a conventional process computer with software comprising necessary algorithms, models and reference sets. If it is desirable only to determine the moisture content and wood structure before and/or drying process, the measurement cell is advantageously arranged in connection to the means for input and output, respectively, of piles of timber in the oven, autoclave or drying room.

EXAMPLE 4, CHIPS FOR PULP AND BOARD PRODUCTION

At production of pulp, paper and board, for instance chip boards, it is of great value to know the quality condition of the wooden raw material, preferably chips, supplied to the

process. The invention is thereby used, by using the influence that the dielectric properties of the chips have on a spectrum of radio frequency radiation, to determine two or more of the following quality determining properties; moisture content, content of extract substances, presence of rot damages and if such are present, type of microorganism and the degree of rot, type of wood for instance deciduous wood or coniferous wood and by mixed wood, the distribution between the different wood types. Furthermore, the following variables are normally determined independent of the electromagnetic radiation measurements; weight, volume and temperature of the chips. These variables are mainly used according to the invention to determine absolute values of certain of the quality determining variables. Measurement cell, evaluation unit and control unit are preferably arranged as in example 1. In many cases, the evaluation unit and control unit are interconnected with or integrated in the process control for the first process step, the pulp cooking and then the quality variables determined according to the invention are used to predict process parameters and initial admixtures of certain admixture substances during the pulp cooking.

EXAMPLE 5, MATTER FOR FERMENTATION

During fermentation, starting from a solid organic material, wood or other plants, it is in the same manner as for production of pulp and paper of great value to know the quality condition of the raw material supplied to the process to avoid disturbances in the process. Fermentation is preferably a batch process and the invention is thereby used, using the influence that the dielectric properties of the organic raw material have on a spectrum of radio frequency radiation, to determine two or more of the following quality determining properties; moisture content, the content of extract substances, the presence of rot damages and if such are present, the type of micro organism and degree of rot,

type of raw material, straw, thicket, chips of deciduous wood, chips of coniferous wood and by mixed raw material the distribution between the different raw materials. The determination is performed on the raw material before input into the process with measurement cell, evaluation unit and control unit arranged in the same manner as in example 1 and 4. Furthermore, the following variables are normally determined independent of the electromagnetic radiation measurements; weight, volume and temperature of the raw material. These variables are mainly used according to the invention to determine absolute values of certain of the quality determining variables. In many cases, the evaluation unit and control unit are, in the same manner as in example 4, interconnected with or integrated in the process control of the fermentation process and whereby the determined quality variables are used to predict process parameters and initial admixtures of certain admixture substances during the fermentation. Measurements where, according to the invention, the influence that the dielectric properties of the fermented pulp have on an emitted primary emission spectrum, which is sent out towards the pulp, may under certain conditions be used to follow the fermentation process.

CLAIMS

1. A method for immediate, continuos and simultaneous qualitative and quantitative determination of a plurality of variables describing the condition or quality of a solid organic matter based on the dielectric properties of said matter, **characterised in that** an organic matter is introduced into a measurement cell comprising a plurality of electrodes,
- that a primary emission spectrum with known spectral data and comprising electromagnetic radiation with a known frequency spectrum of a plurality of wavelengths within the frequency range of 0.3 MHz - 1000 MHz is emitted towards the organic matter in the measurements cell by one or several of said electrodes,
- that at least one secondary spectrum comprising a plurality of wavelengths is generated by said emitted primary spectrum in interaction with the organic matter,
- that said generated secondary spectrum is registered by one or several of said electrodes,
- that said emitted primary emission spectrum and said generated secondary spectrum are compared and
- that alterations in the spectral data between said primary emission spectrum and said generated secondary spectrum are detected, whereupon said detected alterations in spectral data between primary and secondary spectrum are correlated against a plurality of quality describing variables, quality variables, of the investigated matter.

2. A method according to claim 1, **characterised in that** alterations in spectral data between said primary emission spectrum and said secondary generated spectrum are detected as a comparison spectrum comprising a plurality of wavelengths.

3. A method according to claim 2, **characterised in that** said comparison spectrum is achieved as the ratio between said primary spectrum and said secondary spectrum.

4. A method according to claim 2 or 3, **characterised in that** said comparison spectrum is correlated to a plurality of quality variables of an investigated matter of biological origin.

5. A method according to claim 2 or 3, **characterised in that** one or several variables are detected from said comparison spectrum and that from said comparison spectrum detected variable is correlated to a plurality of quality variables of an investigated matter of biological origin.

6. A method according to any of the preceding claims, **characterised in that** additionally at least one variable is determined independent of the electromagnetic measurements,
- that said comparison spectrum and/or in another manner detected alterations of spectral data between said primary emission spectrum and said secondary generated spectrum are combined with the independent variable to a data matrix and that this data matrix is correlated against quality variables of the investigated matter.

7. A method according to any of the preceding claims, **characterised in that** said comparison spectrum and/or in another manner detected alterations of spectral data between said primary emission spectrum and said secondary generated spectrum are correlated to a plurality of quality variables of an investigated matter by multivariate data analysis.

8. A method according to any of the claims 1 to 7, **characterised in that** said comparison spectrum and/or in another manner detected alterations of spectral data between said primary emission spectrum and said secondary generated spectrum are correlated to a plurality of quality variables by using Partial Least Square regression, (PLS).

9. A method according to any of the preceding claims, **characterised in that** the present value for a plurality of quality variables are determined, that at least one determined quality variable is compared by a drawn-up guideline value for this variable, that the discrepancy between present value and guideline value is determined and that a process, in which said matter is included is adjusted by said determined discrepancy.

10. A method according claim 9, **characterised in that** said discrepancy is determined for a raw material, an admixture substance or an intermediate product in a process and said process in a following step is adjusted by said discrepancy.

11. A method according to claim 9, **characterised in that** said discrepancy is determined for a product, an intermediate product or an end product of a process, and that the former steps in said process are adjusted by said discrepancy to correct the quality of the product.

12. A method according to any of the preceding claims, **characterised in that** said comparison spectrum and/or in another manner detected alterations of spectral data between said primary emission spectrum and said

secondary generated spectrum are correlated to a plurality of quality variables by a neural network.

13. A method according to any of the preceding claims, **characterised in that** said secondary generated spectrum is obtained in form of a transmittance spectrum, generated by the part of said emitted primary emission spectrum that passes through, is transmitted through, said organic matter when said primary emission spectrum is emitted towards said organic matter.

14. A method according to any of the preceding claims, **characterised in that** said organic matter comprises solid components, which fully or partly are separated by a gas.

15. A method according to any of the preceding claims, **characterised in that** the wavelengths of said emitted radiation exceed the cross dimensions of the solid components.

16. Device for accomplishing an immediate, continuos and simultaneous qualitative and quantitative determination of a plurality of variables describing the condition or quality of an organic matter based on the dielectric properties of said matter, **characterised by** a measurement cell and an evaluation unit,
- that said measurement cell comprises one or several electrodes, where at least one of said electrodes is arranged to send out a primary emission spectrum with known spectral data and comprising electromagnetic radiation with a known frequency spectrum of a plurality of wavelengths within the frequency range of 0.3 MHz - 1000 MHz towards an organic matter, of which one or several quality variables are to be determined and at least one of said electrodes is arranged to receive and register a secondary spectrum, which has been

generated in interaction between said matter and said primary spectrum,
- that said evaluation unit comprises means for comparing said primary emission spectrum and said generated secondary spectrum and thereby detect alterations in spectral data between said primary emission spectrum and said generated secondary spectrum and means arranged to correlate said detected alterations in spectral data between said primary emission spectrum and said generated secondary spectrum to a plurality of quality variables of the investigated matter.

17. Device according to claim 16, **characterised in that** said evaluation unit comprises means for comparing said primary emission spectrum and said generated secondary spectrum and present the alterations in spectral data between said primary emission spectrum and said generated secondary spectrum in form of a comparison spectrum.

18. Device according to claim 17, **characterised in that** said evaluation unit comprises means for detecting variables from said comparison spectrum.

19. Device according to any of the claims 16 - 18, **characterised in that** said evaluation unit comprises a neural network.

20. Device according to any of the claims 16 - 18, **characterised in that** said evaluation unit comprises an electronic unit with software for Partial Least Square regression, PLS.

21. Device according to claim 19, **characterised in that** said neural network comprises means for controlling a process from determined discrepancies between an

actual value of a determined variable and a guideline value of the same variable.

22. Device according to claim 20, **c h a r a c t e r i s e d i n t h a t** said unit for PLS comprises means for controlling a process from determined discrepancies between an actual value of a determined variable and a guideline value of the same variable.

23. Device according to any of the claims 16 - 22, **c h a r a c t e r i s e d b y** means for substantially continuously transporting matter for investigation through said measurement cell.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 98/00405

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01N 22/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0395308 A2 (PHILIP MORRIS PRODUCTS INC.), 31 October 1990 (31.10.90), claim 1, abstract ---	1-23
A	WO 9524818 A1 (EKEMAR, LARS), 14 Sept 1995 (14.09.95), cited in the application ---	1-23

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
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"E" erlier document but published on or after the international filing date
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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